[0012] U.S. Pat. No. 5,194,862 by Edwards is based on idea of an array of bistable thin-film sensing elements that are activated by touch to obtain x-y coordinates for a multiplicity of touch points. Edward's concept uses one bi-stable sensor for each pixel that is interrogated and is reset by scanning the rows and columns. A grounded stylus or finger causes each proximal bi-stable circuit in the area to switch states. Thus, multiple touches would set a number of these switches, which would then be read out.

SUMMARY OF THE INVENTION

[0013] The present invention are directed to a touch sensor system that comprises a touch sensor and a controller that allow multiple touches to be sensed and their locations to be determined (termed "MultiTouch"). The touch sensor can be transparent, translucent or opaque, depending upon the intended application. The touch sensor further comprises a set of electrodes and conductive bands coupled to the touch region. An electronic controller is attached to energize and read the coordinate locations and to provide data to a host computer or information processing system. The concept is called "Digalog," which refers to reading coordinate pairs by obtaining digital information for one axis and analog for the other.

[0014] It is therefore a purpose of the invention to provide an improved touch sensor that allows single or multiple touches to be sensed and individually located.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] **FIG. 1** shows a resistive sensor with multiple electrodes. Equipotential representations are given for a single energized electrode on the lower right.

[0016] **FIG. 2** is a depiction of a Digalog touch sensor with connections to associated energizing circuits.

[0017] **FIG. 3** is an interconnection diagram of a resistive Digalog touch sensor system.

[0018] **FIG. 4** illustrates the number of cycles required to obtain a selected digital resolution.

[0019] **FIG. 5** compares the energy required and cycle time for a conventional 5-wire resistive screen with the Digalog screen at selected resolutions.

[0020] **FIG. 6** illustrates a Send and Receive Unit composed of a MultiTouch screen together with a processor with visual display and audio output.

[0021] **FIG. 7** illustrates a local Send and Receive Unit in communication with remote Send and Receive Units.

[0022] **FIG. 8** illustrates a TransTouch sensor on which an arbitrary shaped object is placed.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0023] Several designs of touch screens are described to illustrate the flexibility of the Digalog concept. In each case, use is made of a surface which is made electrically conductive with a suitable coating, e.g. indium tin oxide (ITO), and an electrically conductive cover sheet that can be brought into contact to make potential or current measurements. An illustrative design is shown in **FIG. 1**, even though it does not have MultiTouch capability, and furthermore, it is not a likely competitor for present single-point touch screens. This design would use two arrays of electrodes **11** and **12** on as resistive surface **10**. The simplest switching logic to use with this design would be one in which the top electrodes **11** of the sensor are held at a single constant potential and the bottom electrodes **12** are energized individually at a different potential. The potential contours **13** are nonlinear as shown by one example in **FIG. 1**. In principle, the location of a single touch can be determined by its potential as a function of the electrode energized. This design is not satisfactory, since it is limited to single point operation, due to current flow between any two points connected with the conductive cover sheet. Thus, there is no hope for a multi-touch function with this design. Furthermore, to determine the location of a single touch point, the individual lower segments would have to be scanned, for example, by grounding each of the small segments one at a time while leaving all the others floating. In other words, this simplest attempt to use the Digalog concept would be implemented by measuring the potential at a particular point while each strip is activated and then determining the extreme potential to find the nearest electrode. The distribution of equipotentials, as shown in **FIG. 1** for one activated electrode, would cause the determination of coordinates of the touch to be unreliable. The combined deficiencies of single point measured, the need for an elaborate scanning logic to find the extreme potential, and the relatively high power consumption are serious limitations in this design. While the scheme could be used in principle to obtain single touch points, it most likely will not be competitive with existing single-point technology.

[0024] A much more promising design is illustrated in **FIG. 2**, where all segment pairs are now electrically isolated from each other with an insulating line between them. The touch sensor is comprised of a substrate **1**, and a set of conducting bands **3**, which are insulated from one another and which are individually connected to electrodes **2**. In a preferred embodiment, the substrate **1** is transparent and may be composed of glass, plastic or another insulating material. In this embodiment, the conducting bands **3** are also transparent and may be composed of conducting tin oxide that is applied to the substrate. Electrodes **2** provide electrical connections to the ends of the conducting bands **3** and may be composed of metals, such as gold, chromium, nickel, silver or other highly conductive material that may be required to obtain a good electrical connection to circuits **5** and **6**. Conducting leads connect the electrodes **2** to circuits **5** and **6**, which energize individual and groups of conducting bands **3**. This design readily achieved by using modern patterning techniques.

[0025] In one preferred embodiment, the touch sensor is configured with a conducting cover sheet that comes into electrical contact with the bands at the touched areas. Coordinates are determined along an axis perpendicular to the bands by the presence or absence of an electrical signal on the cover sheet as the conducting bands are sequentially energized by an external controller. The orthogonal coordinate or location along each band that is in contact with the cover sheet is determined in an analog fashion. Sequential activation of the bands in coordination with amplitude measurements allows simultaneous plurality of contacts to be individually mapped.